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AUDIENCE DIVERSION DUE TO CABLE TELEVISION:
AN APPLICATION OF NONLINEAR, NONDIAGONALLY WEIGHTED,
GENERALIZED LEAST SQUARES

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March 1980

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PREFACE

This paper is an abridgment of work done at Rand for the Federal Communications Commission's *Inquiry into the Economic Relationship between Television Broadcasting and Cable Television*, Docket 21284 (Park, 1979a,b,c). It may be of interest to applied econometricians because of the use of an ordinary nonlinear regression package to obtain generalized least squares (GLS) estimates of a model with complex error covariance matrix. Transformations are commonly used on linear models to obtain GLS estimates using OLS programs; their application to nonlinear models is somewhat different and may (or may not) have some methodological novelty.

ABSTRACT

A model of television audience shares is estimated and applied to simulate the effect of cable TV carrying distant signals on local stations' audience shares. The model is nonlinear, with a complex error covariance matrix; transformations are used to obtain generalized least squares estimates using an ordinary nonlinear regression package. The conclusion: TV broadcasting will continue to prosper, despite increasing competition from cable.

ACKNOWLEDGMENTS

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CONTENTS

I. INTRODUCTION

In 1972, the Federal Communications Commission adopted rules for cable television that, with minor modifications, remain in force today.[1] The rules are a cautious attempt "to get cable moving so that the public may receive its benefits without, at the same time, jeopardizing the basic structure of over-the-air television."[2] The dilemma arises because of cable's carriage of television signals from distant markets, in addition to those of local stations. On one hand, the additional diversity offered by cable is valued by consumers;[3] some 14 million households in this country now pay a monthly fee for cable service.[4] On the other hand, distant signals divert some audience from local stations, and hence decrease their advertising revenues. If the diversion were sufficiently large, it might cause the stations to cut back on the quality of their programming, or even, conceivably, force them off the air. In promulgating its cable television rules, the FCC was attempting to balance the potential gains to cable subscribers against the potential losses to those who do not subscribe.

The Commission adopted its rules in the face of considerable uncertainty as to what the effect of cable on broadcasting actually would be. It had before it studies by broadcast and cable interests and disinterested parties that seemed to show the possibility of a wide range of effects--all the way from severe harm to, in certain circumstances, substantial help. One reason that the studies disagreed is that there were very few data to go on. Although two national rating services collect detailed data on television audiences, they did not at that time keep separate track of cable and non-cable

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[1] FCC (1972).

[2] FCC (1971, p. 5).

[3] One study puts the amount that consumers would be willing to pay for additional signals very high, for example, 1 percent of household income for a third network station. See Noll, Peck, and McGowan (1973, p. 288).

[4] *Television Digest*, March 5, 1979.

viewing; there was almost no direct evidence about how cable households divide their viewing time between local and distant signals.

In the face of this uncertainty, the Commission chose to act cautiously and incrementally. The 1972 rules allow cable systems within 35 miles of a city with a television station to carry a very limited number of distant signals[1]--small enough to preclude any substantial risk of serious harm to broadcasting, yet large enough, it was hoped, to encourage the expansion of cable into new areas, particularly large markets with good off-the-air television service.

The Commission intended to watch what would happen under the 1972 rules and to take further action, if warranted, as additional information became available. It took a major step in this monitoring process in 1977 when it opened its *Inquiry into the Economic Relationship between Television Broadcasting and Cable Television*. The *Inquiry* has led to a *Proposed Rulemaking* that would remove most of the restrictions on distant signal carriage by cable systems.

This paper is an abridgement of my contribution (1979a, b, c) to the FCC's *Inquiry*. It makes use of newly available data to estimate the effect of distant signals on local stations' audience size. In Section II I discuss the advantages of the new data, specify a model of TV station audience shares, and present estimates of the model. In Section III the estimates are applied to project changes in local stations' audience due to cable TV in a variety of situations. Although the projected losses vary depending on market and cable system characteristics, none seems large enough to cause alarm. The evidence summarized in this paper leads me to believe that TV broadcasting will continue to prosper, despite increasing competition from cable.

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[1]Systems located outside any 35-mile zone may carry as many signals as they choose to.

II. DATA AND AUDIENCE SHARE MODEL

THE DATA

The starting point for my analysis is data on cable and off-the-air television viewing in 166 counties selected by the FCC Cable Bureau staff. Each of the chosen counties has, according to FCC records, only one cable system in operation. These data are much "cleaner" than those used in earlier studies,[1] in the following sense. Earlier studies used market-level audience data. These data lumped together cable and non-cable audience and aggregated over a much larger geographical area than a single county. This raises a difficult problem for analyses that attempt to relate audience shares to the choice of signals available, because that choice varies widely within any given television market. There are typically many different cable systems in a market, each offering its own package of television signals. Off-the-air service can differ greatly from cable service and can in addition vary widely from place to place within the market; for example, overlapping signals from adjacent markets may be available in some places but not in others.

These problems are minimized in my data base; I can relate audience behavior to a well-defined set of signal choices. Only counties with a single cable system in operation are included in the data base; thus all cable households in one of my counties can watch exactly the same signals. Although the same is not perfectly true for non-cable households, it is certainly a much better approximation for county data than it is for market data, since the county is a much smaller geographical area.

The data base was reduced from 166 to 121 counties in two stages. First, four counties were dropped because unlisted stations

[1] I am thinking particularly of my own contribution to the FCC proceeding that led to the 1972 rules (Park, 1970) and the well-known book on television economics by Noll, Peck, and McGowan (1973). For a summary of early results, see Besen et al. (1976).

attract a significant share of cable audience. American Research Bureau (ARB) data do not separately identify foreign stations, stations that individually attract very small shares, and possibly others. Such stations taken together attract over 10 percent of either full-day or prime-time audience on the cable systems in four counties. I dropped these counties because the set of listed stations does not reasonably approximate the actual signal choice set.

Second, 41 more counties were dropped because they are apparently located near the fringes of their markets. I want to draw inferences about areas that would be affected by a relaxation of the distant signal restrictions. These areas are all within 35 miles of a television city. In such areas, one would ordinarily expect to find the bulk of the off-the-air television audience watching local stations. If the local station share of off-the-air audience is small in some county, that county is probably not representative of the closer-in areas of present interest. I arbitrarily set the cutoff at 70 percent and exclude 41 counties with local station shares of less than 70 on a full-day basis. Data for the remaining 121 counties are reproduced in full in Park (1979c).

AUDIENCE SHARE MODEL

I hypothesize that each station can be assigned an "attractiveness index" a_i such that the audience tends to divide among available signals in proportion to $a_i/\Sigma a_i$, where the summation is over all of the available signals. I assume that attractiveness indices are (largely) determined by the type of station and estimate indices for the following ten station types:

NVL: local network VHF
NUL: local network UHF
IVL: local independent VHF
IUL: local independent UHF

NVD: distant network VHF not blacked out[1]
NUD: distant network UHF not blacked out
NVDB: distant network VHF blacked out
NUDB: distant network UHF blacked out
IVD: distant independent VHF
IUD: distant independent UHF[2]

I allow the attractiveness indices to differ off the air and on the cable. In particular, I expect them to be higher on the cable for local UHF stations and for all distant stations, because of improved reception on the cable. Thus the model is

$$S_{io} = \Sigma a_{jo} D_{ij} / \Sigma a_{jo} M_{jo} + u_{io}$$

and

$$S_{ic} = \Sigma a_{jc} D_{ij} / \Sigma a_{jc} M_{jc} + u_{ic}, \tag{1}$$

where S_{io} and S_{ic} are audience shares for the i^{th} station off the air and on the cable respectively, the summations are over the ten station types, D_{ij} is a dummy variable equal to 1 if the i^{th} station is of type j and 0 otherwise; M_{jo} and M_{jc} are the numbers of available signals of type j off the air and on the cable, respectively; and u_{io} and u_{ic} are error terms to be specified further below. In matrix notation, (1) is the nonlinear regression model

$$S = f(D,M;\, a) + u, \quad E(uu') = V. \tag{2}$$

---

[1] Some distant network stations are blacked out on cable at times when they broadcast the same program as a local network affiliate. This so-called "nonduplication protection" is available on request to stations located within 35 miles of a cable system (or within 55 miles for stations in below-100 markets). If asked to do so, the cable system must delete programs broadcast by any lower priority station, when those programs duplicate those of the requesting station. See FCC (1972, Subpart E), for details.

[2] In initial regressions, I also included four types of noncommercial stations (local and distant, VHF and UHF), but these consistently failed to achieve indices that were significantly different from zero in either a statistical or a practical sense.

ERROR STRUCTURE

In estimating the model, I take account of three ways in which the error structure departs from the classical least squares assumption that $V = \sigma^2 I$.

1. Each observation on S is based on a number of diaries placed in sample households. The sample size N_i varies widely, from a low of 10 to a high of over 400. I expect the observations to be more reliable when they are based on larger samples, with error variance roughly inversely proportional to sample size.
2. After correction for sample size, I expect off-the-air observations to have higher error variance than cable observations. This is [illegible] variation in reception quality will add noise to off-the-air observations while signal quality is more nearly uniformly good on the cable.
3. It seems likely that some of the unspecified influences on S that are included in the error term affect in the same way both cable and non-cable households in the same county. An unusually popular station off the air is apt to be unusually popular on the cable as well. I therefore expect the cable and off-the-air error terms to be positively correlated within counties.

These three observations imply the following structure for the error covariance matrix. Order the observations by county, and within each county put the off-the-air observation first and the cable observation second for each of the local stations in turn. Then

$$V = \begin{bmatrix} A_1 & 0 \dots & 0 \\ 0 & A_2 \dots & 0 \\ \vdots & \vdots & \vdots \\ 0 & 0 \dots & A_n \end{bmatrix},$$

where n is the number of local stations in the sample (358) and

$$A_i = \begin{bmatrix} \sigma_o^2/N_{io} & \sigma_o\sigma_c\rho/\sqrt{N_{io}N_{ic}} \\ \sigma_o\sigma_c\rho/\sqrt{N_{io}N_{ic}} & \sigma_c^2/N_{ic} \end{bmatrix} .$$

N_{io} is the number of diaries in non-cable homes in the i^{th} county, N_{ic} is the number of diaries in cable homes, σ_o^2 is the off-the-air error variance, σ_c^2 is the cable error variance, and ρ is the correlation of off-the-air and cable errors within counties.

The generalized least squares (GLS) estimates of the attractiveness indicies $\hat{a}$ are obtained by minimizing

$$\hat{u}'V^{-1}\hat{u} = (S - f(D,M;\ \hat{a}))'\ V^{-1}(S - f(D,M;\ \hat{a})) \quad .$$

In this case we have

$$V^{-1} = \begin{bmatrix} A_1^{-1} & 0 & \cdots & 0 \\ 0 & A_2^{-1} & \cdots & 0 \\ \vdots & \vdots & & \vdots \\ 0 & 0 & \cdots & A_n^{-1} \end{bmatrix},$$

where

$$A_i^{-1} = \frac{1}{1-\rho^2} \begin{bmatrix} N_{io}/\sigma_o^2 & -\rho\sqrt{N_{io}N_{ic}}/\sigma_o\sigma_c \\ -\rho\sqrt{N_{io}N_{ic}}/\sigma_o\sigma_c & N_{ic}/\sigma_c^2 \end{bmatrix} .$$

Then $(1-\rho^2)V^{-1}$ can be decomposed as R'R where

$$R = \begin{bmatrix} B_1 & 0 & \cdots & 0 \\ 0 & B_2 & \cdots & 0 \\ \vdots & \vdots & & \vdots \\ 0 & 0 & \cdots & B_n \end{bmatrix}$$

and

$$B_i = \begin{bmatrix} \sqrt{1-\rho^2}\,\sqrt{N_{io}}/\sigma_o & 0 \\ -\rho\sqrt{N_{io}}/\sigma_o & \sqrt{N_{ic}}/\sigma_c \end{bmatrix} .$$

Thus one can obtain GLS estimates from an ordinary nonlinear regression of the transformed variables $S^* = RS$ on the transformed functions $f^*(D,M;\ a) = Rf(D,M;\ a)$. For off-the-air observations,

$$S^*_{io} = \sqrt{1-\rho^2}\,(\sqrt{N_{io}}/\sigma_o)\ S_{io}$$

and

$$f^*_{io}\ (D,M;\ a) = \sqrt{1-\rho^2}\,(\sqrt{N_{io}}/\sigma_o)\ f(D_i,M_o;\ a_o)\ . \qquad (3)$$

For cable observations,

$$S^*_{ic} = (\sqrt{N_{ic}}/\sigma_c)\ S_{ic} - \rho(\sqrt{N_{io}}/\sigma_o)\ S_{io}$$

and

$$f^*_{ic}(D,M;\ a) = (\sqrt{N_{ic}}/\sigma_c)\ f(D_i,M_c;\ a_c) - \rho(\sqrt{N_{io}}/\sigma_o)\ f(D_i,M_o;\ a_o)\ . \qquad (4)$$

This is easily accomplished using, for example, the SAS nonlinear regression procedure NLIN.[1] The trick is to include both off-the-air and cable data in each observation and use a dummy variable to turn on either transformation (3) or transformation (4) as appropriate.

[1] See Appendix for a program listing.

I replace the unknown ρ, σ_o, and σ_c in the transformation matrix R with consistent estimates based on the residuals from first-stage regressions.[1] The first-stage regressions were run for off-che-air and cable observations separately, weighted for sample size only. Root mean squared error from each equation was used to estimate $\sigma_o = .992$ and $\sigma_c = .458$; the correlation of residuals from the off-the-air equation with residuals from the cable equation was used as an estimate of $\rho = .657$.

The model is estimated using 716 observations on off-the-air or cable audience shares for all of the local stations[2] in 121 counties, together with numbers of each station type available off the air or on cable. "Local" stations are those assigned to the ADI[3] market of which the county is a part; "distant" stations are stations from other markets.[4]

ESTIMATED ATTRACTIVENESS INDICES

Table 1 shows the estimated audience share equation for the full day.[5] The estimated coefficients are for the most part in accord with

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[1]The first-stage regressions may be found in Park (1979b, Appendix Table A.1).

[2]In initial work, I used observations on distant as well as local station shares, 1417 in all, in a pooled regression. The results were plausible, but an F test indicated, at well beyond the .01 level, that separate equations for local and distant stations were required. There is another reason for excluding observations on (at least) one station per county: Because shares for all stations must total one, one observation per county is redundant.

[3]Area of dominant influence, defined by the American Research Bureau (ARB) to be all those counties with which a market's stations attract a plurality of TV viewing.

[4]Exception: stations are counted as local if they receive nonduplication protection against some other station, and they are counted as distant if they are blacked out to provide nonduplication protection to some other station, regardless of whether the county is in their ADI or not.

[5]Estimates for other time periods (portions of the broadcast day, for example, prime time alone) are in Park (1979b).

Table 1

SECOND STAGE UNCONSTRAINED AUDIENCE SHARE EQUATION

		Network[a]			Independent[a]	
		L	D	DB	L	D
Full Day						
Off-the-air viewing						
	VHF	1.00	.07	.11	.57	-.25
		(b)	(1.8)	(2.8)	(3.2)	(2.4)
	UHF	.45	.12	.23	.28	-.03
		(9.7)	(.5)	(1.0)	(4.0)	(.1)
Cable viewing	VHF	1.00	.38	.19	.56	.40
		(b)	(9.1)	(6.7)	(3.4)	(6.0)
	UHF	.65	.15	.15	.28	.25
		(12.0)	(1.1)	(1.0)	(3.5)	(3.3)

NOTES: The dependent variable is the station share of total audience over the full broadcast day. Estimated coefficients are "attractiveness indices" in equation (1). Asymptotic t-statistics are in parentheses.

[a]L indicates local stations. D indicates distant stations not blacked out. DB indicates distant network stations blacked out to provide nonduplication protection to local stations.

[b]This coefficient is normalized to one as a reference value--not estimated.

prior expectations. Local stations handicapped by lack of network affiliation or by UHF transmission have lower indices than do network VHF stations; independent UHF stations, which suffer from both handicaps and which, in addition, often broadcast weaker programs than do VHF independents, have the lowest indices of all local stations. Local network UHF stations have higher indices on the cable than they do off the air, undoubtedly because reception is improved by cable. A similar effect is not apparent for local independent UHF stations, but this is probably because their attractiveness indices are estimated less precisely than are those of network stations.

The indices for distant stations off the air do not convey much information because they are highly reception-dependent. They depend mostly on how close out-of-market stations happen to be to the sample counties. The estimated negative indices for some such stations are anomalies, but not very important ones. I do not use these values in the application of the model. Furthermore, when I reestimated the equations with all indices constrained to be non-negative, the other coefficients changed very little.[1]

Distant stations on the cable generally have smaller indices than do comparable local stations. The index for distant network VHF stations not blacked out is quite precisely estimated to be about 38 percent of that of local VHF network stations. The index for distant VHF independents is about 70 percent of the index for their local counterparts. Indices for distant UHF stations on the cable are smaller than those for comparable VHF stations, presumably reflecting less attractive programming on the UHF stations, and also perhaps residual picture quality differences even on the cable.

CONSTRAINED ESTIMATES

Cable should improve reception, and hence attractiveness, of all local UHF stations. This effect shows up strongly for network

[1] See Park (1979b, Appendix Table A.3).

stations, but is obscured by relatively imprecise estimates for independents on the cable. I can increase the precision by "pooling" the experience of network and independent UHF stations in the following sense: I assume that cable increases the attractiveness of local UHF stations (both network and independent) by the same multiple, K. That is, if the off-the-air indices are a_{NUL} and a_{IUL}, the cable indices are $K(a_{NUL})$ and $K(a_{IUL})$ where K is to be estimated.

In addition, I assume that being blacked out part of the time on the cable reduces the attractiveness of distant network stations, both VHF and UHF, by the same multiple, BLK. That is, if the cable indices for stations that are not blacked out are a_{NVD} and a_{NUD}, then for those that are blacked out $a_{NVDB} = BLK(a_{NVD})$ and $a_{NUDB} = BLK(a_{NUD})$.

The constrained estimates are shown in Table 2. Both the K constraint and the BLK constraint are acceptable hypotheses (using an F test at the .05 level). The improvement factor K for local UHF stations on the cable is quite precisely estimated to be 1.37. The blackout factor BLK for distant stations blacked out to provide nonduplication protection is also fairly precisely estimated to be .50.

Table 2 also shows several statistics based on residuals from the second stage constrained equation. The components of the transformation matrix R ($\hat{\sigma}_o$, $\hat{\sigma}_c$, and $\hat{\rho}$) are changed very little from those based on the first-stage regressions. Thus it seems likely that iterative estimation, which would be quite expensive, would not change the second-stage estimates very much. R_1^2 is for the equation as actually estimated using transformed variables, that is, the regression of S* on f*(D,M; a). R_2^2 shows how well the estimated equation does in explaining variance in untransformed S.[1]

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[1]R_2^2 is calculated as (VAR-SSE)/VAR, where VAR = $\Sigma(S-\bar{S})^2$ and SSE = $\Sigma(S-\hat{S})^2$. $\bar{S}$ is the mean value of S, and $\hat{S}$ represents values predicted using GLS estimates of the attractiveness indices in (1).

Table 2

SECOND STAGE CONSTRAINED AUDIENCE SHARE EQUATION

	Network[a]			Independent[a]							
	L	D	DB	L	D	K	BLK	$\hat{\sigma}$	$\hat{\rho}$	R_1^2	R_2^2
Full Day											
Off-the-air viewing								.999	.672	.671	.440
VHF	1.00	.07	.10	.57	-.25						
	(b)	(1.8)	(2.8)	(3.3)	(2.4)						
UHF	.47	.14	.19	.23	-.03						
	(10.1)	(.6)	(.9)	(4.0)	(.1)						
Cable viewing											
VHF	1.00	.38	.19	.56	.40	1.37	.50	.460			
	(b)	(9.1)	(d)	(3.4)	(6.0)	(12.7)	(4.9)				
UHF	.64	.16	.08	.32	.25						
	(c)	(1.4)	(d)	(c)	(3.4)						

NOTES: The dependent variable is the station share of total audience over the full broadcast day. Estimated coefficients are "attractiveness indices" in equation (1). Asymptotic t-statistics are in parentheses.

[a]L indicates local stations. D indicates distant stations not blacked out. DB indicates distant network stations blacked out to provide nonduplication protection to local stations.

[b]This coefficient is normalized to one as a reference value--not estimated.

[c]This coefficient is constrained to equal K times the corresponding off-the-air coefficient. K is an estimated multiplier.

[d]This coefficient is constrained to equal BLK times the corresponding cable coefficient for distant network stations that are not blacked out. BLK is an estimated multiplier.

III. APPLYING THE ESTIMATES TO PROJECT AUDIENCE DIVERSION DUE TO CABLE TELEVISION

Table 3 uses the audience share equation to simulate the effect of cable on local station audience in three hypothetical markets, chosen to represent top-50, second-50, and below-100 market conditions. For each hypothetical market, I show the effect of three different distant signal packages:

- Those allowed by existing rules.
- A larger number of stations that might be carried if the present rules regarding independent signal carriage were relaxed.
- All of the above plus additional stations that might be carried if rules regarding carriage of network signals were also relaxed.

Near-term projections for each of the resulting nine cases are shown in Table 3. The near-term projections are based on present cable penetration levels in markets of each type. The projections show audience if there is cable in the market, as a percentage of audience if there is no cable. Audience if there is no cable is calculated using the off-the-air attractiveness indices in Table 2. Audience if there is cable is a weighted average of shares calculated for cable and off-the-air viewing, with cable penetration (p) and 1-p as weights. I use attractiveness indices estimated for distant VHF stations on the cable for all distant signals.[1]

In the larger (three-network) markets, projected audience diversion in the near term is minimal--6 percent or less under present regulations, and 11 percent or less under the most relaxed regulations. In smaller markets (fewer than three networks), projected

[1] Specifically, I use .38 for primary network signals (which are not blacked out), .19 for duplicate network signals (which are), and .40 for independents.

Table 3

NEAR-TERM EFFECT OF CABLE ON LOCAL STATION AUDIENCE SHARE IN REPRESENTATIVE MARKETS UNDER PRESENT AND POTENTIAL RELAXED CABLE REGULATION

Network		Independent		Distant Stations			Cable Pene-tration[a]	Index of Local Station Audience[b] If Cable Exists				
								Network		Independent		
VHF	UHF	VHF	UHF	Prim. Net.	Depl. Net.	Ind.		VHF	UHF	VHF	UHF	Total
Top-50 Markets												
3	0	1	1	0	0	2	.16	97		97	102	97
				0	0	6	.16	93		93	97	93
				0	3	6	.16	92		92	96	93
Second-50 Markets												
2	1	0	0	0	0	2	.18	94	100			95
				0	0	5	.18	90	94			91
				0	3	5	.18	89	93			90
Below-100 Markets												
1	1	0	0	1	0	1	.31	87	94			89
				1	0	4	.31	80	85			81
				1	3	4	.31	78	82			79

[a] Average present penetration in markets of each type. Data supplied by FCC Cable Bureau.

[b] Average audience over the full broadcast day. The base (100 percent) is the audience if cable does not exist; it assumes that all the audience watches local stations in the absence of cable (that is, there are no overlapping signals from adjacent markets).

diversion ranges up to 13 percent currently, and 22 percent under relaxed regulations. In all cases, UHF stations are not hurt as much by cable as are VHF stations; in some instances, they may actually be helped.

Long-term diversion patterns[1] are similar to the short-term patterns, but the magnitudes are larger. Projected diversion ranges up to 25 percent in markets with three network stations under the most relaxed cable regulations, and much higher than that in markets with only one or two stations.

COMPARISON WITH OTHER STUDIES

In (1979a), I also made projections that are comparable to those in five other studies of audience diversion due to cable. Although the five studies use quite different methods and data, their results are broadly consistent with this one. The five other studies are my own early report on cable and broadcasting (1970), similar estimates in Noll, Peck, and McGowan (1973), and studies filed in the FCC's current *Inquiry* by the National Association of Broadcasters, the National Cable Television Association, and the Motion Picture Association of America (all 1978).

QUALIFICATIONS

The simplifying assumptions embodied in my model necessarily distort reality. Here are the most important ways in which they can affect my projections.

1. My projections assume that everyone would watch local stations if there were no cable. This is a fairly good approximation in most large markets, but not in many smaller markets where stations from adjacent markets attract substantial audiences off the air. Indeed,

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[1]Based on predicted ultimate equilibrium cable penetration levels; see Park (1979b, p. 12, Table 4).

a study by the National Cable Television Association (1978) shows that audience diversion off the air is almost as large as it is on the cable in many of the markets that it studied. On this ground, my projections will substantially *overstate* the audience loss due to cable in many smaller markets.

2. I make no allowance for diversion of cable audiences to new services such as pay-TV. To the extent that new services grow to attract substantial audience shares, my projections will tend to *understate* audience diversion due to cable.
3. Attractiveness indices estimated for distant VHF stations are used for all distant signals. To the extent that less attractive UHF stations are actually carried, the projections may tend to *overstate* actual diversion.
4. The form that I assumed for my audience share equation assures that the estimated effect of a sixth imported independent station will be a substantial fraction of the estimated effect of the first--nearly half as large in most markets. There is some case study evidence that, in reality, the effect of additional stations falls off much more rapidly than that.[1] If so, all of my projections will tend to *overstate* the effect of relaxing the regulations governing distant signal carriage.

The net effect of these qualifications, in my judgment, is to assure that most of my projections are conservative. Audience diversion due to cable is not likely to exceed the levels projected.

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[1] FCC (1979, pp. 74-88).

Appendix

SAS PROGRAM LISTING

```
//P0780R00 JOB (2958,200,133),'    ED PARK    ',CLASS=N
// EXEC SAS,OPTIONS='S=72,NONEWS'
//FT20F001 DD DSN=P.P0780.A2883.FCC.AUGDATA,DISP=SHR
//SYSIN DD *
DATA;
COMMENT
        NV,...,IU ARE STATION TYPE DUMMIES THAT CORRESPOND
        TO D(I,J) IN THE TEXT.
        NNVLO,...,NIUDC ARE NUMBERS OF STATIONS OF EACH TYPE
        OFF THE AIR AND ON THE CABLE RESPECTIVELY.  THESE
        CORRESPOND TO M(J,O) AND M(J,C) IN THE TEXT.
        SHRO AND SHRC ARE OFF-THE-AIR AND CABLE SHARES, CORRESPONDING
        TO S(I,O) AND S(I,C).
        INTABO AND INTABC ARE SAMPLE SIZES N(I,O) AND N(I,C).
        C IS A DUMMY VARIABLE EQUAL TO 0 FOR OFF-THE-AIR
        OBSERVATIONS AND 1 FOR CABLE OBSERVATIONS.
;
INPUT (NV NU IV IU NNVLO NNULO NNVDO NNUDO NNVDBO NNUDBO
                   NIVLO NIULO NIVDO NIUDO SHRO   INTABO
                   NNVLC NNULC NNVDC NNUDC NNVDBC NNUDBC
                   NIVLC NIULC NIVDC NIUDC SHRC   INTABC C) (RB4.);
INFILE FT20F001;
WTO=SQRT(INTABO)/.992;
WTC=SQRT(INTABC)/.458;
SHR=(1.-C)*SQRT(1.-.657**2)*WTO*SHRO+C*(WTC*SHRC-.657*WTO*SHRO);
PROC MEANS;
COMMENT
        DO THE UNCONSTRAINED ESTIMATION.
;
PROC NLIN ITER=20 METHOD=MARQUARDT;
COMMENT
        A1,...,A9 ARE OFF-THE-AIR ATTRACTIVENESS INDICIES CORRESPONDING
        TO THE A(I,O) IN THE TEXT.
        C1,...,C9 ARE CABLE ATTRACTIVENESS INDICIES CORRESPONDING
        TO A(I,C).
;
PARAMETERS A1=.40 A2=.50 A3=.23 A4=.02 A5=.12 A6=.13 A7=.29 A8=-.16
           A9=.27
           C1=.57 C2=.51 C3=.23 C4=.36 C5=.15 C6=.20 C7=.18 C8=.44
           C9=.29;
TOPO=NV+A1*NU+A2*IV+A3*IU;
TOPC=NV+C1*NU+C2*IV+C3*IU;
BOTTOMO=NNVLO+A1*NNULO+A2*NIVLO+A3*NIULO+A4*NNVDO*A5*NNUDO
        +A6*NNVDBO+A7*NNUDBO+A8*NIVDO+A9*NIUDO;
BOTTOMC=NNVLC+C1*NNULC+C2*NIVLC+C3*NIULC+C4*NNVDC*C5*NNUDC
        +C6*NNVDBC+C7*NNUDBC+C8*NIVDC+C9*NIUDC;
MODEL SHR=(1.-C)*SQRT(1.-.657**2)*WTO*(TOPO/BOTTOMO)
          +C*(WTC*(TOPC/BOTTOMC)-.657*WTO*(TOPO/BOTTOMO));
DER.A1=((1.-C)*SQRT(1.-.657**2)-C*.657)*WTO
       *(BOTTOMO*NU-TOPO*NNULO)/BOTTOMO**2;
DER.A2=((1.-C)*SQRT(1.-.657**2)-C*.657)*WTO
       *(BOTTOMO*IV-TOPO*NIVLO)/BOTTOMO**2;
DER.A3=((1.-C)*SQRT(1.-.657**2)-C*.657)*WTO
       *(BOTTOMO*IU-TOPO*NIULO)/BOTTOMO**2;
DER.A4=((1.-C)*SQRT(1.-.657**2)-C*.657)*WTO
       *(-TOPO*NNVDO)/BOTTOMO**2;
DER.A5=((1.-C)*SQRT(1.-.657**2)-C*.657)*WTO
       *(-TOPO*NNUDO)/BOTTOMO**2;
DER.A6=((1.-C)*SQRT(1.-.657**2)-C*.657)*WTO
       *(-TOPO*NNVDBO)/BOTTOMO**2;
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DER.A7=((1.-C)*SQRT(1.-.657**2)-C*.657)*WTO
       *(-TOPO*NNUDBO)/BOTTOMO**2;
DER.A8=((1.-C)*SQRT(1.-.657**2)-C*.657)*WTO
       *(-TOPO*NIVDO)/BOTTOMO**2;
DER.A9=((1.-C)*SQRT(1.-.657**2)-C*.657)*WTO
       *(-TOPO*NIUDO)/BOTTOMO**2;
DER.C1=C*WTC*(BOTTOMC*NU-TOPC*NNULC)/BOTTOMC**2;
DER.C2=C*WTC*(BOTTOMC*IV-TOPC*NIVLC)/BOTTOMC**2;
DER.C3=C*WTC*(BOTTOMC*IU-TOPC*NIULC)/BOTTOMC**2;
DER.C4=C*WTC*(-TOPC*NNVDC)/BOTTOMC**2;
DER.C5=C*WTC*(-TOPC*NNUDC)/BOTTOMC**2;
DER.C6=C*WTC*(-TOPC*NNVDBC)/BOTTOMC**2;
DER.C7=C*WTC*(-TOPC*NNUDBC)/BOTTOMC**2;
DER.C8=C*WTC*(-TOPC*NIVDC)/BOTTOMC**2;
DER.C9=C*WTC*(-TOPC*NIUDC)/BOTTOMC**2;
COMMENT
        DO THE CONSTRAINED ESTIMATION.
;
PROC NLIN ITER=20 METHOD=MARQUARDT;
PARAMETERS A1=.40 A2=.50 A3=.23 A4=.02 A5=.12 A6=.13 A7=.29 A8=-.16
           A9=.27
                    C2=.51          C4=.36 C5=.15                  C8=.44
           C9=.29 BLK=.6 K=1.5;
TOPO=NV+A1*NU+A2*IV+A3*IU;
TOPC=NV+K*A1*NU+C2*IV+K*A3*IU;
BOTTOMO=NNVLO+A1*NNULO+A2*NIVLO+A3*NIULO+A4*NNVDO*A5*NNUDO
        +A6*NNVDBO+A7*NNUDBO+A8*NIVDO+A9*NIUDO;
BOTTOMC=NNVLC+K*A1*NNULC+C2*NIVLC+K*A3*NIULC+C4*NNVDC*C5*NNUDC
        +BLK*C4*NNVDBC+BLK*C5*NNUDBC+C8*NIVDC+C9*NIUDC;
MODEL SHR=(1.-C)*SQRT(1.-.657**2)*WTO*(TOPO/BOTTOMO)
          +C*(WTC*(TOPC/BOTTOMC)-.657*WTO*(TOPO/BOTTOMO));
DER.A1=((1.-C)*SQRT(1.-.657**2)-C*.657)*WTO
       *(BOTTOMO*NU-TOPO*NNULO)/BOTTOMO**2
       +C*WTC*(BOTTOMC*K*NU-TOPC*K*NNULC)/BOTTOMC**2;
DER.A2=((1.-C)*SQRT(1.-.657**2)-C*.657)*WTO
       *(BOTTOMO*IV-TOPO*NIVLO)/BOTTOMO**2;
DER.A3=((1.-C)*SQRT(1.-.657**2)-C*.657)*WTO
       *(BOTTOMO*IU-TOPO*NIULO)/BOTTOMO**2
       +C*WTC*(BOTTOMC*K*IU-TOPC*K*NIULC)/BOTTOMC**2;
DER.A4=((1.-C)*SQRT(1.-.657**2)-C*.657)*WTO
       *(-TOPO*NNVDO)/BOTTOMO**2;
DER.A5=((1.-C)*SQRT(1.-.657**2)-C*.657)*WTO
       *(-TOPO*NNUDO)/BOTTOMO**2;
DER.A6=((1.-C)*SQRT(1.-.657**2)-C*.657)*WTO
       *(-TOPO*NNVDBO)/BOTTOMO**2;
DER.A7=((1.-C)*SQRT(1.-.657**2)-C*.657)*WTO
       *(-TOPO*NNUDBO)/BOTTOMO**2;
DER.A8=((1.-C)*SQRT(1.-.657**2)-C*.657)*WTO
       *(-TOPO*NIVDO)/BOTTOMO**2;
DER.A9=((1.-C)*SQRT(1.-.657**2)-C*.657)*WTO
       *(-TOPO*NIUDO)/BOTTOMO**2;
DER.C2=C*WTC*(BOTTOMC*IV-TOPC*NIVLC)/BOTTOMC**2;
DER.C4=C*WTC*(-TOPC*(NNVDC+BLK*NNVDBC))/BOTTOMC**2;
DER.C5=C*WTC*(-TOPC*(NNUDC+BLK*NNUDBC))/BOTTOMC**2;
DER.C8=C*WTC*(-TOPC*NIVDC)/BOTTOMC**2;
DER.C9=C*WTC*(-TOPC*NIUDC)/BOTTOMC**2;
DER.BLK=C*WTC*(-TOPC*(C4*NNVDBC+C5*NNUDBC))/BOTTOMC**2;
DER.K=C*WTC*(BOTTOMC*(A1*NU+A3*IU)-TOPC*(A1*NNULC+A3*NIULC))
      /BOTTOMC**2;
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